

**ZOOM SYSTEM****CROSS REFERENCE TO RELATED APPLICATIONS**

**[0001]** This application claims priority of the German patent application 102 49 702.8 filed October 25, 2002 which is incorporated by reference herein.

**5      FIELD OF THE INVENTION**

**[0002]** The invention concerns a zoom system, for example for a surgical microscope.

**BACKGROUND OF THE INVENTION**

**[0003]** Zoom systems, i.e. variable magnification systems, are used today in almost every surgical microscope. One important representative thereof is the M690 (Leica brochure: Ophthalmologie [Ophthalmology] M1-602-0de-1.94-SCH, January 1994 printing).

**[0004]** The zoom system in this known microscope comprises an even number of optical elements. It has a four-element configuration and is constructed symmetrically. Each two lens groups are identical, and the groups are arranged in mirror-image fashion with respect to each other. The two outer lens groups are arranged immovably, the two inner groups movably. The two outer lens groups have positive refractive power, the two inner ones negative refractive power. Both focusing and a change in magnification are possible therewith.

**[0005]** The inventor has recognized that the systems existing today are capable of being improved in terms of chromatic aberrations, in particular those of the secondary system, and with regard to curvature of field and astigmatism. It is likewise desirable to keep the overall length short without having to sacrifice a high zoom factor.

**25      SUMMARY OF THE INVENTION**

**[0006]** Proceeding from this recognition, it is thus the object of the invention to improve the previously occurring chromatic aberrations, especially those of the

second spectrum, in the context of apochromaticity; and to eliminate the disadvantages listed above and keep the overall length of the zoom short.

[0007] This object is achieved by the use of materials (glass types) having special optical properties as well as particular design features, such as the geometry of the boundary surfaces and of the air spaces.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The drawings schematically depict a zoom system according to the present invention for a surgical microscope, wherein:

Fig. 1 is a schematic diagram of a zoom system formed in accordance with an embodiment of the present invention, wherein movable lens groups of the zoom system are shown at a first limit position;

Fig. 2 is a schematic diagram of the zoom system shown in Fig. 1, wherein the movable lens groups are shown at an intermediate position giving 1:1 magnification, and an optical axis and light beam are also shown; and

Fig. 3 is a schematic diagram of the zoom system shown in Fig. 1, wherein movable lens groups of the zoom system are shown at a second limit position.

#### DETAILED DESCRIPTION OF THE INVENTION

[0009] Reference is made to Figs. 1-3. Light beam 6 (shown in Fig. 2 only) proceeding from a viewed specimen (not depicted) is directed, at a first lens group 2 which comprises two lenses 11 and 12 and has positive refractive power, onto a lens group 3 that comprises two lenses 13 and 14 and has negative refractive power. From lens group 3, light beam 6 is conveyed onto a lens group 4 that comprises two lenses 15 and 16, and further directed onto a lens group 5 that comprises two lenses 17 and 18. Lens groups 2, 3, 4, and 5 are embodied as cemented elements each having two individual lenses. Lens groups 2 and 5 on the one hand, and 3 and 4 on the other hand, are respectively identical to one another and arranged in mirror-image fashion. Lens groups 2 and 5 are arranged immovably; lens groups 3 and 4 are mounted movably. The axial displaceability of lens groups 3 and 4 along an

optical axis 1 of the zoom system makes possible focusing onto the specimen and modification of the focal length.

[0010] Optical glass can be characterized by  $n_d$ ,  $v_d$ ,  $P_{g,F}$  and  $P_{C,t}$ , where

$n_d$  designates the refractive index,  $v_d = \frac{n_d - 1}{n_F - n_C}$  the Abbé number,

5  $P_{g,F} = \frac{n_g - n_F}{n_F - n_C}$  the relative partial dispersion for wavelengths  $g$  and  $F$ , and

$P_{C,t} = \frac{(n_C - n_t)}{n_F - n_C}$  the relative partial dispersion for wavelengths  $C$  and  $t$ . For

most glasses ("standard glasses"), the following linear equations ("standard straight lines") are approximately valid:

$$P_{n_{g,F}} = 0.6438 - 0.001628 \cdot v_d,$$

10  $P_{n_{C,t}} = 0.5450 + 0.004743 \cdot v_d.$

[0011] The glasses used in this invention do not obey this linear equation. The deviations of the relative partial dispersions from the standard straight lines are

$$|P_{g,F} - P_{n_{g,F}}| > 0.001$$

and/or

15  $|P_{C,t} - P_{n_{C,t}}| > 0.002.$

[0012] The glasses used are listed in Table 1.

Table 1:

Material	$n_d$	$v_d$	Delta $P_{g,F}$	Delta $P_{C,t}$
A	1.72342	37.95	0.0035	0.0023
B	1.49700	81.63	0.0319	-0.1133
C	1.57956	53.87	-0.0012	-0.0053
D	1.76182	26.52	0.0150	0.0046

5      **[0013]**      As a result of the special choice of materials, and the geometries of the  
 boundary surfaces (S1 through S12) and air or gas spaces (air gaps) (AG1 through  
 AG3) described in Table 2 below, chromatic aberrations (especially those of the  
 secondary spectrum) are reduced, and an improvement in the context of  
 apochromaticity, as well as a reduction in astigmatism and flatness, are achieved.  
 The field curvature of the new zoom system according to the present invention thus  
 10 corresponds approximately to the field curvature of the eyepiece.

Table 2:

Boundary surface or Medium	Radius $r_i$ (mm)	Thickness or air space $d_i$ (mm)	Material	$n_d$	$v_d$
S1	29.48				
Lens 11		2.0	A	1.72342	37.95
S2	18.62				
Lens 12		3.5	B	1.49700	81.63
S3	-176.25				
Air Gap 1		31.65...23.18...2.00	Air		
S4	-123.57				
Lens 13		2.0	C	1.57956	53.87
S5	12.93				
Lens 14		3.0	D	1.76182	26.52
S6	19.69				
Air Gap 2		14.70...2.64...15.35	Air		
S7	-19.69				
Lens 15		3.0	D	1.76182	26.52
S8	-12.93				
Lens 16		2.0	C	1.57956	53.87
S9	123.57				
Air Gap 3		2.65...23.18...31.65	Air		
S10	176.25				
Lens 17		3.5	B	1.49700	81.63
S11	-18.62				
Lens 18		2.0	A	1.72342	37.95
S12	-29.48				

5 [0014] In contrast to conventional systems, the design features and special selection of the glass types for the lenses of the zoom system according to the present invention result in a short overall length of 70 mm, despite the very high zoom factor of 6X. Selection of adjacent glass types and correspondingly corrected air spaces makes possible, with fundamentally the same configuration, zoom factors between 5X and 8X with overall lengths between approximately 60 mm and approximately 100 mm.

**[0015]** The symmetrical arrangement of each two identical lens groups makes possible, as is known per se, a small number of different lens groups and individual lenses. This is true in particular for a stereomicroscope, in which the number of lens groups is doubled because two optical channels are used parallel to one another.

5 **[0016]** The zoom system described above can be utilized both in a stereomicroscope having one main objective and two partial beam paths, and in single-channel or stereoscopic single-channel microscope systems. The lens diameter of the zoom system can preferably correspond to the lens diameter of the main objective.

## 10 PARTS LIST

- 1 Optical axis of zoom system
- 2 Lens group 1
- 3 Lens group 2
- 4 Lens group 3
- 15 5 Lens group 4
- 6 Light beam
- 11 Lens (material A)
- 12 Lens (material B)
- 13 Lens (material C)
- 20 14 Lens (material D)
- 15 Lens (material D)
- 16 Lens (material C)
- 17 Lens (material B)
- 18 Lens (material A)